2001: an Amateur Radio Space Odyssey on the International Space Station

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Introduction

In 1996, after the first International Partners meeting of the newly formed Amateur Radio on the International Space Station (ARISS) team, we all walked away "cautiously optimistic" that we would be able to develop, deploy and operate a ham radio station on the ISS. This optimistic dream from a handful of internationally-based amateur radio operators has now turned into reality. The year 2001 will go down in history as the year that the ARISS amateur radio station became fully operational.

It was a good thing that those involved in the hardware development and deployment had no idea of the significant challenges that faced them. Otherwise they would have all quit prematurely. The challenges that this international team endured were immense. We were the first "payload" to fly on ISS and no one—USA's NASA or the Russian Space Agency—really knew how we should be qualified. We repeated several flight qualification tests 2 and 3 times to satisfy all the different organizations requirements—the Shuttle, the USA ISS team and the Russian ISS team. We also had to overcome the cultural difference hurdles that result from working as a fully integrated international team. A couple of weeks prior to the launch of the initial ISS Ham radio hardware, we were still hanging on the edge of a precipice. The issue this time was that we had not satisfied the Russian EMI requirements. But we persevered, we made it happen.

This paper will provide an overview of the equipment currently on-board the ISS, the hardware currently in the queue for deployment over the next 12 months, and our long-term vision for the future.

Human Spaceflight and Amateur Radio—a perfect pair

The Amateur Radio on the International Space Station (ARISS) represents a melding of the teams that have pioneered the development and use of amateur radio equipment on human spaceflight vehicles. The Shuttle/Space Amateur Radio Experiment (SAREX) team enabled Owen Garriott, W5LFL, to become the first astronaut ham to use amateur radio from space. Calling "W5LFL from the Space Shuttle Columbia" Owen made hundreds of QSOs on the STS-9 space shuttle mission in 1983. Since then, amateur radio teams in the U.S. (SAREX), Germany, (SAFEX), and Russia (Mirex) have led the development and operation of amateur radio equipment on board NASA's Space Shuttle and the Russian MIR space station. The ARISS team, a delegation of 10 countries, was formed in 1996 to develop, fly, and operate ham radio equipment on the International Space Station.

Through ARISS, the ham radio community can talk to the astronauts and cosmonauts on-board ISS. The primary goals of ARISS operations are fourfold: 1) educational outreach through crew contacts with schools, 2) random contacts with the Amateur Radio

public, 3) scheduled contacts with the astronauts' friends and families and 4) ISS-based communications experimentation. A few schools are selected from around the world for scheduled contacts with the orbiting ISS crew. Ten or more students at each school ask the astronauts questions, and the nature of these contacts embodies the primary goal of the ARISS program, -- to excite student's interest in science, technology and amateur radio. More than 200 schools have participated in a scheduled contact since the first amateur radio equipment was flown on the Space Shuttle.

Ham Shack Location

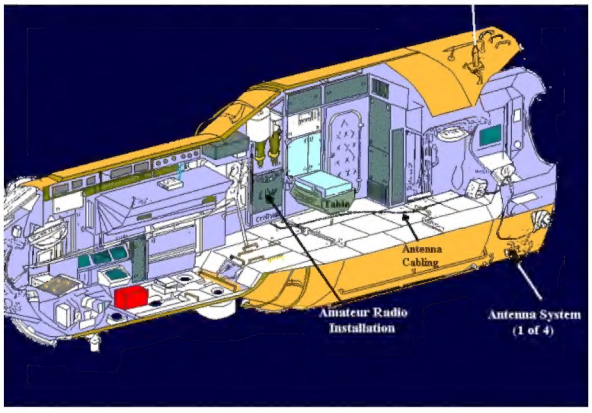
The ISS Ham equipment will reside in two locations. 2 meter operations will primarily be conducted in the Russian Functional Cargo Block (FGB), named Zarya, using Russian antennas used to dock the FGB. These antennas, designed for use near the 2-meter band, (see figure 1) are no longer used by the Russians and can be used by the ISS Ham team permanently. This is the current location of the ISS ham radio station.

FGB 2 Meter Antenna Locations
Figure 1

In late 2000, a set of 4 antenna systems developed by the ISS Ham team are expected to be deployed. Once these antennas are deployed and checked out, the primary location of the ham shack will reside in the Russian Service Module (SM) named Zvezda. See figure 2. The ham station will be installed

Service Module and FGB
Figure 2

at location 426 in the SM, right next to the dining table. See figure 3. Simultaneous multi-band operation can be conducted with these two ham shack locations.

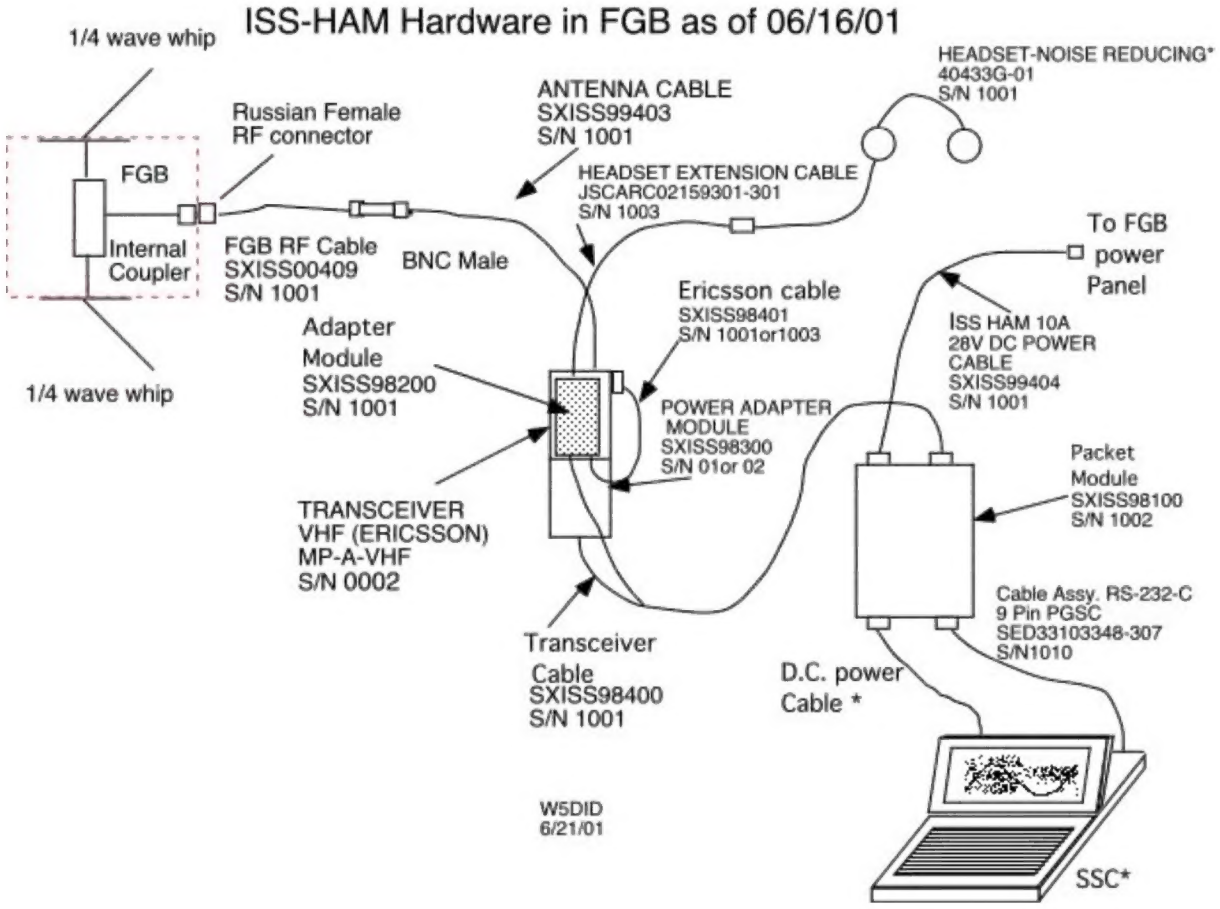


ISS Ham Hardware Location in
Service Module
Figure 3

Hardware Overview

The initial ISS Ham radio system was launched on-board the STS-106 Space Shuttle Atlantis on September 8, 2000. The initial

ISS Ham radio hardware consists of two hand-held Ericsson transceivers, a power adapter, an adapter module, an antenna system, a packet module, a headset assembly, and the required cable assemblies (see figures 4 and 5). The ham radio station is capable of operating in either the voice or data (packet) mode with amateur stations within line-of-sight of the ISS. This configuration can be operated in the attended mode for voice communications and either the attended or automatic mode for packet communications. The function of each of the components that comprise the ISS Ham radio is summarized below:



ISS Ham Hardware Configuration
Figure 4

a. **Hand-held Ericsson (M-PA Series) Transceivers** – There are two transceivers on board: A VHF radio that receives and transmits FM voice or packet radio signals in the two meter (144 to 146 MHz) Amateur Band, and a UHF radio that receives and transmits FM voice or packet

Photo of Flight Hardware
Figure 5

radio signals in the 70 centimeter (435-438 MHz) Amateur Band. Both radios are Ericsson (M-PA) series commercial grade radios. These radios look identical in size and features, but are specially tuned to support the different bands. Each radio is programmed with 4 banks of 16 frequency pairs (for a total of 64 discrete frequency pairs. To date, only the 2 meter radio has been used. The radio transceiver receives 7.5 VDC from the ISS through a DC/DC power converter located in the power adapter. Buttons on the top of the housing are used to control the transceiver, with information being displayed on an eight-digit display on the front of the radio. Up to 5 Watts of output power is available on any one of the possible channels. The radio is built within a cast aluminum housing. The basic radio measures 2.7x1.5x4.6 inches (69x38x117 mm). See figure 6.

Transceiver & Power Adapter
Figure 6

b. **Power Adapter** – The Power Adapter consists of a specially developed 12 V to 7.5 V DC/DC power converter that converts the 12 VDC received from the power supply in the packet module to 7.5 VDC that powers the transceiver. A 12.0-to-7.5 Switching Mode Voltage Regulator is built into a standard, polymeric Ericsson Battery casing. The power adapter snaps onto the base of the transceiver in place of the battery pack interface (see figure 6).

c. **Adapter Module** - Provides a means of interconnecting the ISS Ham transceiver with the supplied headset assembly, as well as, a standard crew personal tape recorder (see figure 7). It also provides the audio interface to the packet module and will become the primary interface with the SSTV hardware.

Adapter Module
Figure 7

d. **Station Support Computer (SSC)** – This ISS-provided hardware was supposed to serve as a data terminal for packet radio operations. Due to lack of the required number of computers on-board ISS, the ham radio station has not been able to have the use of a computer. The SSC will also serve as the video and software interface for SSTV system that is planned to be deployed in the near future. Negotiations are underway to make sure that a dedicated SSC will be available for ARISS operations.

e. **Packet Module** – The packet module contains the primary power supply for the

Packet Module
Figure 8

ISS ham radio station. A maximum of 3 amps of current at 28 V can be provided to the various elements that make up the ISS Ham system. Embedded in the packet module is a PacComm Picopacket Terminal Node Controller (TNC). See figure 8.

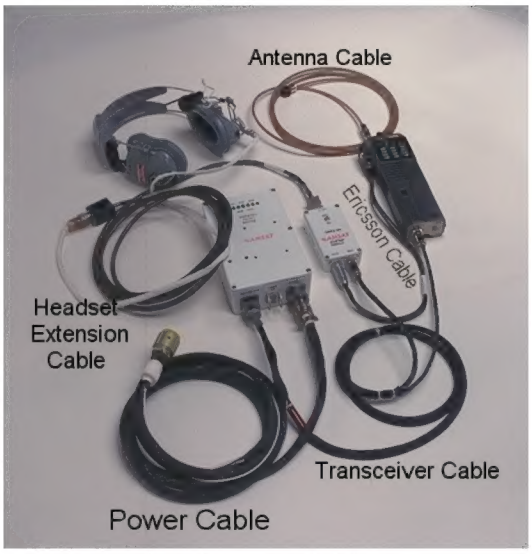
Headset Assembly
Figure 9

f. **Headset assembly**: A David Clark aviation-type headset, similar to that used on several shuttle missions, was configured for the ISS ham radio station. See figure 9.

g. **Cable interfaces**: Below is a list of cable interfaces required: See figure 10.

I. antenna cable – connects radio transceiver to antenna connection on service module or in the FGB.
II. Ericsson cable – attached to radio transceiver, it connects the radio to the adapter module.

III. transceiver cable – provides power from the packet module to the power adapter, and provides audio link from the packet module to the adapter module.
IV. ISS HAM 10A 28VDC Power Cable – Connects 28 VDC (Russian) to 28VDC (U.S.) using a standard Service Module/FGB 10A outlet.
V. Headset extension cable – connects between the adapter module and the headset assembly. It extends the distance between the headset and the ISS Ham system, allowing the crewmember greater mobility. It has a push-to-talk switch near the crew interface.
VI. RS232 cable – provides a serial link between the packet module and the SSC laptop computer.
VII. SSC DC Power cable –a SSC may be connected to the POWER OUT port of the packet module through the use of this cable.



Equipment Cables
Figure 10

Future Hardware Deployments

Packet Module Upgrade

To date, the packet system has not been connected to an SSC laptop due to the lack of sufficient laptops on ISS. Also, shortly after the packet system was turned-on for general use, it was discovered that the battery used to backup the RAM had died. Because of these two events, the packet system has been operating in digipeat mode using the ROM defaults (including the Nocall callsign). An upgraded packet module is expected to correct these problems and add new capabilities. The new TNC will include a specially developed ROM with the standard ISS Ham defaults, Russian and USA labels, a new battery, and extended memory (up to 1 meg). Since the packet module serves as the power supply for the station, the ARISS team has decided to leave both packet modules on-board ISS. The older version will serve primarily as a power supply for one of the stations (FGB or SM). The newer version will provide the packet radio capability. The new packet module was launched on the STS-105 Discovery mission on August 10, 2001.

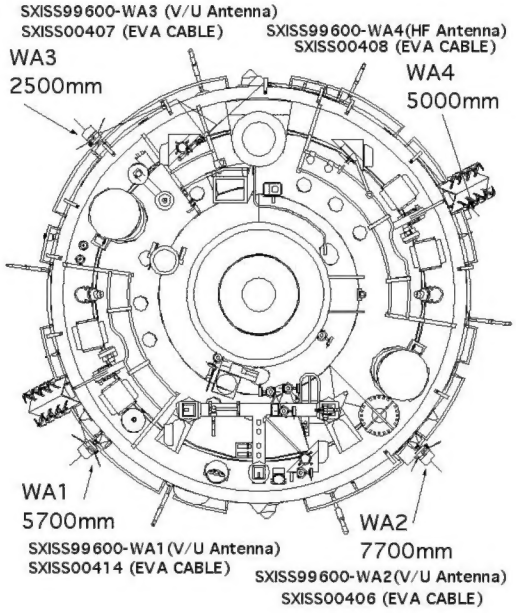
Antenna Assemblies

The specially designed ISS Ham antenna assemblies will permit operations on HF (20 meters, 15 meters & 10 meters), VHF (2-meters), UHF (70cm), and the microwave bands (L and S band) These dual-use antenna also permit the reception of the Russian Glisser EVA video signals (2.0 GHz). This dual-use capability is the primary reason the ARISS team received access to 4 antenna feedthroughs located on the outside of the Service Module. A total of four antenna systems were developed to get maximum use of the antenna feedthroughs. These will be installed around the periphery of the far end of the Service Module. See figure 11. Three of the antennas (WA1-WA3) will include the VHF/UHF flexible tape antennas. WA4 will

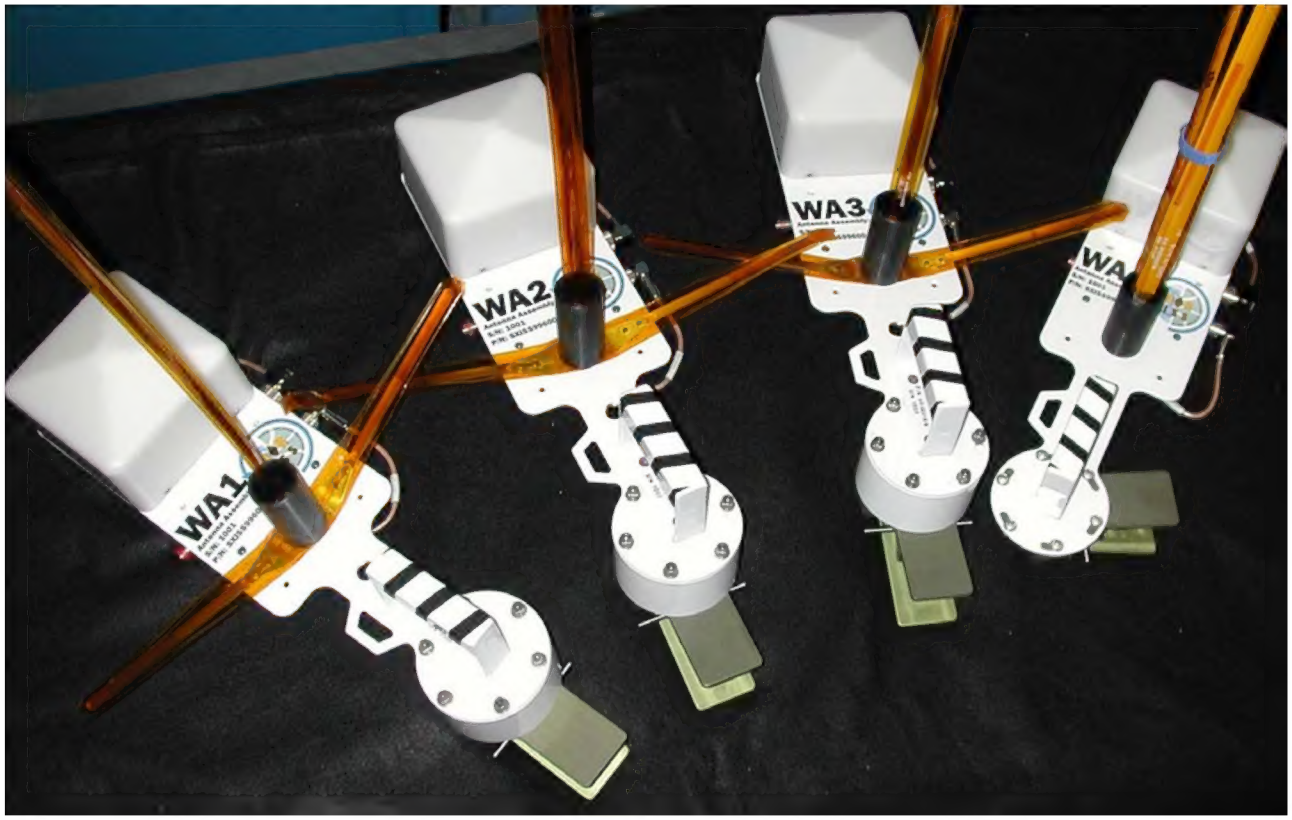
include a 2.5 meter HF antenna. The antenna systems were developed by the U.S., Italian, and Russian ARISS partners.

The antenna assembly consists of a mounting plate, spacer, Russian handrail clamp, VHF/UHF (or HF) metal flexible tape antenna with delrin mounting collar, an L/S band flat spiral antenna with a delrin radome cover, a diplexer and interconnecting RF cables. See figure 12. The antennas will be mechanically mounted on Russian handrails, illustrated in figure 13, using the "clothespin type" handrail clamp. RF connection is accomplished using 4 feedthroughs that have a special EVA connector attached. See figure 14.

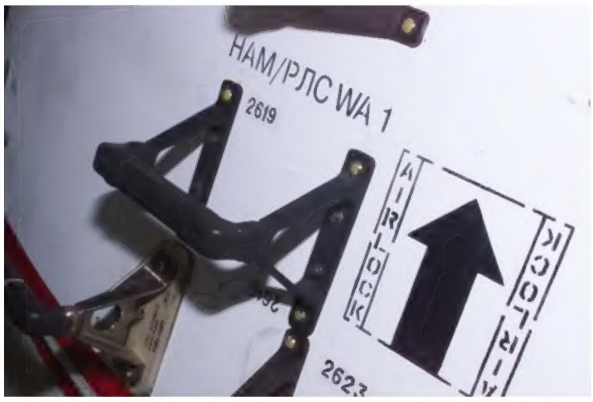
The antenna systems are currently scheduled for launch on the UF-1/STS-108 flight. This flight is tentatively scheduled for the end of



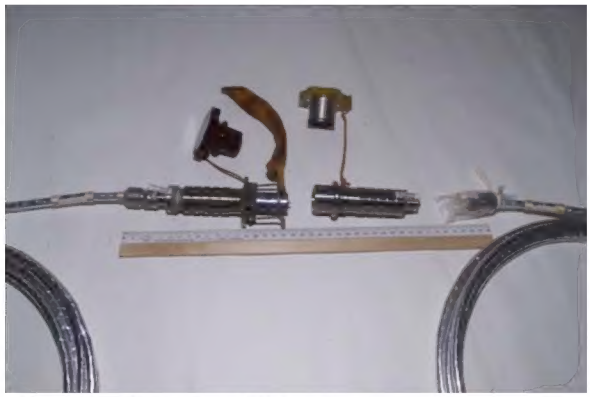
Antenna Location View from End of Service Module
Figure 11



Antenna Systems WA1-WA4
Figure 12



Antenna Handrail WA1
Figure 13

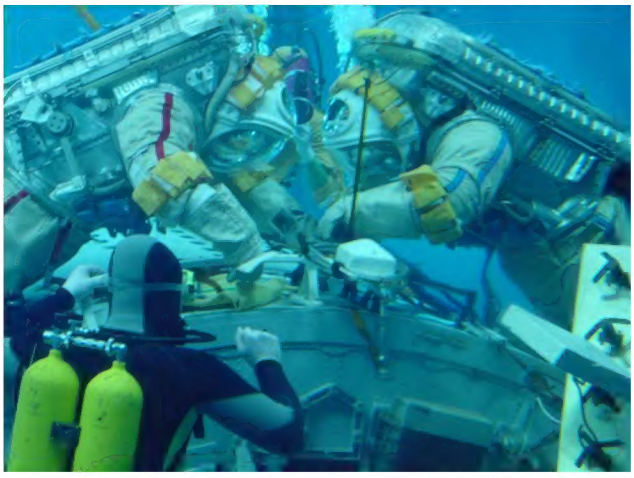


Russian EVA Connectors
Figure 14

November. The antennas will be deployed during an EVA (spacewalk) by the Expedition 4 crew. This crew has performed extensive training of the antenna installation in the Russian Hydrolab water tank located at the Gagarin Cosmonaut Training Center (GCTC) in Star City Russia. See figure 15.

SSTV

The Slow Scan Television (SSTV) system for the ISS ham radio station is currently in development. This system will consist of a software interface, developed by the MAREX-NA team and a hardware interface, developed by the ARISS Hardware team. Prototype hardware and software systems have been developed and the flight system fabrication has started. The SSTV system will allow digital still pictures to be uplinked and downlinked in both crew-tended and autonomous modes. The ARISS team expects the SSTV system to be operational on ISS sometime in 2002.



EVA Training for Antenna Installations
Figure 15

Conclusions

The year 2001 will be long remembered as the year that the ARISS team pioneered a new facet of amateur radio---permanence on the International Space Station. In the future, there will be new equipment, new modes of operation and exciting QSOs. Enjoy the QSOs, experimentation and School Group Contacts. And remember the international team that made it happen---ARISS.

For more information on the ARISS program, you are welcome to surf the ARISS web page at: http://ariss.gsfc.nasa.gov